Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
Expanding Flexible Use of the 3.7 to 4.2 GHz Band	)	GN Docket No. 18-122

PETITION FOR RECONSIDERATION OF CHARTER COMMUNICATIONS, INC.

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Charter Communications, Inc. ("Charter") submits this Petition for Reconsideration of the *C-Band Order*[1] in the above-captioned proceeding, pursuant to Section 1.429 of the Federal Communications Commission's ("Commission" or "FCC") rules.[2] Specifically, Charter respectfully requests that the Commission require 3.7-4.2 GHz Band ("C-Band") flexible use licensees to make Time Division Duplex ("TDD") synchronization available to Citizens Broadband Radio Service ("CBRS") licensees and users (collectively, "operators") upon request. Without such synchronization, C-Band base stations will interfere with, and significantly impede, the ability of CBRS base stations to communicate with CBRS user equipment operating in both the Priority Access License ("PAL") and General Authorized Access ("GAA") spectrum blocks. An FCC mandate is necessary to guard against incentives for uncompetitive behavior and to protect competition for all types of operators, including new entrants.

[1] *In re Expanding Flexible Use of the 3.7 to 4.2 GHz Band*, Report and Order and Order of Proposed Modification, 35 FCC Rcd 2343 (2020) ("*C-Band Order*").

[2] 47 C.F.R. § 1.429.

INTRODUCTION AND SUMMARY

Charter has been an active participant in both the C-Band and CBRS proceedings, and strongly supports the Commission's efforts to make additional mid-band spectrum available for flexible wireless use. Access to mid-band spectrum promises to enable numerous 5G opportunities throughout this country and enhance the future of mobile connectivity. The FCC's recently adopted rules for the CBRS band enable and encourage efficient and innovative uses of spectrum, including by rural and smaller providers and new entrants. Growing deployments in the CBRS band continue to advance wireless competition and broadband deployment, including in less densely populated areas and rural communities. Without effective safeguards, however, the C-Band base stations will overwhelm CBRS base stations and significantly impede these innovative services across the entire CBRS band.

While the Commission historically has avoided putting downlink bands next to uplink bands, TDD uses the same spectrum for both downlink and uplink operations. The juxtaposition of two TDD bands therefore creates the possibility that downlink operations in one band will be next to uplink operations in an adjacent band. Consequently, if a C-Band base station using TDD is transmitting while a nearby CBRS base station is trying to receive, the CBRS base station will suffer blocking interference—that is, it will be overwhelmed, and will not be able to hear the user equipment across the entire CBRS band.[3] The solution is to ensure that base stations on both bands transmit at the same time. This can be achieved through TDD synchronization. When both bands are transmitting at the same time, the potential for downlink-to-uplink interference disappears. As demonstrated below, requiring C-Band licensees to make

[3] Because of the interoperability requirement in the CBRS band, CBRS base stations must be able to receive across the entire 150 megahertz of the band. *See* 47 C.F.R. § 96.39(b).

TDD synchronization available to CBRS operators upon request is readily achievable and well within the Commission's authority to order.[4]

The *C-Band Order* concluded that standard out-of-band emission ("OOBE") limits will be sufficient to ensure that C-Band operations can coexist alongside CBRS operations without causing harmful interference.[5] The Commission denied requests to require TDD synchronization, relying instead on simply "encourag[ing] parties to explore synchronization of TDD operations."[6] As the attached analysis makes clear, however, in the absence of such a requirement, harmful interference is highly likely.

While carriers with spectrum in both bands will have an interest in engaging in internal coordination,[7] C-Band licensees without CBRS operations could have the incentive to *resist* cooperation with CBRS operators who are likely to offer competing services. The absence of a synchronization requirement could also unfairly advantage large carriers over new entrants and smaller carriers because large carriers are more likely to have access to alternative spectrum on which to offload their CBRS operations to mitigate the effects of interference from the C-Band.

This harm to competition directly contradicts the intent of the CBRS proceeding, which is to create innovative competitors and improve the efficient use of spectrum. Although industry working groups have been organized to consider interference between the two spectrum bands, and they are likely to encourage TDD synchronization, an industry working group cannot require

[4] Charter recognizes that some CBRS operators may utilize non-LTE equipment that is not capable of TDD synchronization. Mindful of this fact, Charter's proposal is to require C-Band licensees to make TDD synchronization available *upon request* of a CBRS operator, and does not impose any obligation on CBRS operators.

[5] *See C-Band Order*, 35 FCC Rcd at 2486 ¶ 397.

[6] *Id.* at 2486 ¶ 396.

[7] *See id.*

a C-Band licensee to make synchronization available if the licensee has an incentive not to help a CBRS competitor.

Charter therefore respectfully requests that the Commission reconsider its determination in the *C-Band Order* and require C-Band licensees to make TDD synchronization available to CBRS operators upon request, in order to mitigate the risk of harmful interference and thereby ensure that both C-Band and the CBRS band are put to their highest and best use in a timely and efficient manner. By requiring C-Band licensees to work cooperatively with CBRS operators to develop an inclusive solution that resolves interference, the Commission can ensure fair competition in both bands.

I. CBRS OPERATIONS WILL EXPERIENCE BLOCKING INTERFERENCE FROM ADJACENT C-BAND LICENSEES WITHOUT TDD SYNCHRONIZATION

In the absence of TDD synchronization, CBRS base stations are likely to experience interference across the entire band due to blocking caused by adjacent C-Band operations. This is because a C-Band base station will overwhelm CBRS base station operations in both the PAL and GAA portions of the band unless operations in both bands are synchronized.

Charter and others have previously explained the potential for GAA users operating immediately below the C-Band to encounter harmful interference,[8] but this problem is not limited to the GAA blocks. As the attached analysis demonstrates, interference from blocking will also affect Blocks 1 through 10, where PALs (as well as GAA) will be located. All blocks in the CBRS band are likely to suffer both coverage loss and throughput reduction without TDD

[8] *See* Letter from Elizabeth Andrion, Senior Vice President, Regulatory Affairs, Charter, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 18-122 et al. (Feb. 6, 2020); Letter from Jennifer M. McCarthy, Vice President, Legal Advocacy, Federated Wireless, Inc., to Marlene H. Dortch, Secretary, FCC, GN Docket Nos. 18-122, 17-258 (Feb. 5, 2020) ("*Federated Wireless Ex Parte*").

synchronization. This harmful interference is inconsistent with the rights of GAA users,[9] and is even more problematic for Priority Access Licensees, which are entitled to operate without harmful interference in the band as well as outside of it.[10]

As the analysis shows, without TDD synchronization, CBRS base stations will not be able to sufficiently reject the incoming transmissions from the C-Band base station in asynchronous TDD operation. The fact that C-Band signals have higher power levels than CBRS serves to worsen the impact to CBRS, but the problem would still exist even if the power levels were similar between the two bands. While the attached analysis focuses on the blocking caused by base stations operating in the C-Band Block A1, Block A2 and the blocks above also have significant interference potential. And importantly, the blocking from the C-Band will affect the CBRS base stations across the entire CBRS band.[11]

Notably, the blocking that results from the inability of a CBRS base station to reject the signal from an adjacent C-Band base station will reduce the coverage of the CBRS base station and diminish its ability to communicate with CBRS user equipment to maintain the required user experience. This will be especially devastating given that next generation equipment and services using CBRS spectrum will likely be available in advance of similar equipment and services built for use in the C-Band. As a result, when C-Band operations are deployed, there

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[9] GAA is a licensed service, albeit licensed by rule, and licensees are entitled to protection against harmful interference from adjacent band operations. *See* 47 U.S.C. § 307(e)(1); *In re Expanding Flexible Use of the 3.7 to 4.2 GHz Band*, Order and Notice of Proposed Rulemaking, 33 FCC Rcd 6915, 6974 ¶ 181 (2018) ("One concern about deploying a robust mobile broadband service adjacent to the Citizens Broadband Radio Service arises from the relatively higher power limits proposed above. One possibility for preventing interference between the services would be to impose adjacent channel power limits that could limit the differential between power levels for adjacent stations operating in the same area.").

[10] *See* 47 C.F.R. §§ 2.102(b), 96.1(b).

[11] *See attachment* at 7-9.

will already be CBRS deployments in the market delivering next-generation wireless networking to consumers that will suddenly be degraded by blocking interference caused by new C-Band operations.[12]

While the Commission explains in the *C-Band Order* how emission limits have proven successful in combating interference from other adjacent services in other mobile service bands,[13] this has generally been between harmonized bands with uplink next to uplink or downlink next to downlink, and such protection will not be sufficient to prevent blocking of CBRS operations by C-Band base stations. Here, the interference problem for CBRS operations is not due to OOBE primarily, but instead is the result of the CBRS receiver's inability to receive a signal at its assigned channel frequency in the presence of a strong signal in the adjacent C-Band given the differentials between the bands and the fact that, in the absence of synchronization, downlink transmissions in the C-Band will be adjacent to uplink transmissions in the CBRS band. The adoption of a synchronization requirement then is the only practical means to resolve this interference and protect the viability of both PAL and GAA operations in the CBRS band.

TDD synchronization is readily achievable. The main element required for TDD synchronization is a common time reference, which can be accomplished with GPS.[14] With that

[12] *Federated Wireless Ex Parte*.

[13] *See C-Band Order*, 35 FCC Rcd 2486 ¶ 397.

[14] *See* Electronic Communications Committee, *ECC Report 216: Practical guidance of TDD networks synchronization* at 2-3 (2014) ("*ECC Report*"). GPS is already widely used for this purpose. *See id*. at 2. A site that cannot get access to GPS can get time information over a network connection, in accordance with standards such as IEEE 1588, or by what 3GPP has described as "Network Listening." Under Network Listening, one base station gets timing information over-the-air from another base station. This was developed specifically so indoor 3GPP small cells can synchronize with outdoor cells that utilize GPS. *See id.* at 11-15.

information, all that is necessary is an agreement on when frames start and the frame configuration.[15] Synchronization must be utilized today within a single TDD network,[16] making the extension of this technical protocol to operations between networks technically straightforward. Successful inter-operator synchronization deployments have been achieved in Italy, Malaysia, Japan, and South Korea.[17] TDD synchronization has been subjected to review by 3GPP[18] as well as the Electronic Communications Committee of the European Conference of Postal and Telecommunications Administrations.[19] And as Verizon notes, "[s]ynchronization is supported by vendors and operators complying with CBRS Alliance specifications."[20]

II. CBRS OPERATORS WITHOUT C-BAND LICENSES WILL BE STYMIED IN THEIR EFFORTS TO RESOLVE THE BLOCKING INTERFERENCE ABSENT A REQUIREMENT FOR TDD SYNCHRONIZATION UPON REQUEST

While the *C-Band Order* "encourage[s] parties to explore synchronization of TDD operations to minimize interference,"[21] C-Band licensees will have little incentive to enter into voluntary commitments with competitors operating in the CBRS band. Reliance on voluntary negotiations also overlooks the fact that, to be effective, TDD synchronization must be implemented on an inclusive and non-discriminatory basis by all affected operators. If carriers with operations in both bands can resolve most interference issues for themselves without engaging with CBRS operators, it is highly unlikely this technical issue will be resolved for all

[15] *See id.* at 3.

[16] *See id.* at 6-7.

[17] *See id.* Annex 3.

[18] *See C-Band Order*, 35 FCC Rcd 2486 ¶ 397.

[19] *See generally ECC Report.*

[20] Letter from Patrick Welsh, Vice President, Federal Regulatory Affairs, Verizon to Marlene H. Dortch, Secretary, FCC, GN Docket No. 18-122 et al., at 2 (Nov. 12, 2019).

[21] *C-Band Order*, 35 FCC Rcd at 2486 ¶ 396.

carriers. Even though the *C-Band Order* indicates the possibility for two carriers to synchronize "using traditional 3GPP methods based on an absolute timing reference,"[22] technical requirements such as these are particularly ill-suited to voluntary action. Agreement by a few willing participants to adhere to certain protocols will not be sufficient to prevent C-Band operations overall from blocking adjacent CBRS operations.

Even assuming that two providers were committed to synchronization, there are no guarantees that they will continue to do so indefinitely. Moreover, the largest wireless carriers that likely will be operating in both the CBRS and C-Band will be better incentivized and positioned to coordinate amongst themselves. One-on-one arrangements between the largest carriers could have an even more perverse effect on smaller providers operating exclusively in the CBRS band as this type of coordination removes much of the broader incentive among adjacent band licensees to identify a band-wide synchronization solution upon the request of smaller carriers and new entrants. The competitive harm to smaller carriers is exacerbated by their lack of spectrum flexibility—these smaller carriers and new entrants are unlikely to have alternative spectrum available in the event of interference.

Additionally, the *C-Band Order*'s observation that, in some instances, operations above and below the band edge "may be synchronized when they are deployed as part of a carrier's network"[23] does not solve the more general concern of C-Band operations blocking the CBRS operations of third parties. Of course, carriers acting in their own self-interest will be motivated to synchronize within their own networks to ensure that their operations in one band do not negatively affect their other operations in another band. But the fact that one carrier alone has

[22] *Id.* at 2486 ¶ 397.

[23] *Id.*

the capability to synchronize its own CBRS and C-Band operations says nothing about whether that carrier will synchronize its C-Band operations with another company's CBRS operations upon request in an effort to solve the broader blocking problem. Indeed, without collective action, there is no guarantee that CBRS operators will be free from blocking interference on a non-discriminatory basis.

It is therefore critical that the Commission require all C-Band licensees to make TDD synchronization available to CBRS operators upon request. Adopting such a synchronization requirement will ensure that the CBRS band is fully utilized. Work to ready this spectrum band for flexible wireless use has been ongoing for years, with both the Commission and industry investing significant resources to ensure timely auction of this spectrum. If interference from C-Band operations is not addressed *ex ante*, it is likely that the need for additional mitigation efforts will further delay widespread use of the CBRS spectrum band, and the accompanying innovative benefits to urban, suburban, and rural areas the FCC and the industry have worked so hard to achieve.

While the *C-Band Order* notes a concern that implementation of a mechanism to ensure TDD synchronization "could hinder efficient 5G deployment in the [C-Band],"[24] the absence of TDD synchronization is more likely to disserve the public interest by delaying and hobbling 5G deployment in the CBRS band as licensees struggle to resolve potential interference concerns. The Commission has certainly seen how adjacent interference issues have delayed the utilization of other spectrum bands for years.[25] It should seek to avoid a similar outcome in the CBRS band

[24] *Id.* at 2485 ¶ 396.

[25] *In re Amendment of Part 27 of the Commission's Rule to Govern the Operation of Wireless Communications Services in the 2.3 GHz Band*, Order on Reconsideration, 27 FCC Rcd 13651, 13660-61, 13666 ¶¶ 18, 31 (2012) (holding that "the need to facilitate wireless broadband operations in the WCS spectrum, coupled with the unique technical challenges associated with

by mandating that C-Band licensees make TDD synchronization available when requested by CBRS operators. Such a requirement imposes no undue burden on C-Band licensees. To the contrary, such a requirement has proven technically and otherwise feasible.[26]

III. THE COMMISSION HAS AMPLE AUTHORITY TO IMPLEMENT A TDD SYNCHRONIZATION REQUIREMENT

The Commission's broad authority to manage the electromagnetic spectrum and mitigate harmful interference between spectrum users provides a solid legal foundation to require C-Band licensees to make TDD synchronization available to CBRS operators upon request.[27] Courts have repeatedly explained that "[t]he Commission's power under [Section] 303(r) is broad."[28] Likewise, Sections 303(e) and (f) give the Commission "broad authority to develop a comprehensive national regulatory system governing telecommunications."[29] Section 303

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allowing a fixed and mobile service to operate adjacent to a broadcasting-satellite service" justifies enacting rules for requiring interference resolution "with more specific obligations and greater regulatory oversight than the Commission requires in other contexts."). Prior to the adoption of these rules, longstanding adjacent band interference concerns effectively delayed utilization of the 2.3 GHz band for wireless broadband services.

[26] *See* pp. 6-7, *supra*.

[27] *See* 47 U.S.C. § 303(e) (requiring the Commission to "[r]egulate the kind of apparatus to be used with respect to its external effects"); *id.* § 303(f) (requiring the Commission to "[m]ake such regulations not inconsistent with law as it may deem necessary to prevent interference between stations"); *id.* § 303(r) (requiring the Commission to "[m]ake such rules and regulations and prescribe such restrictions and conditions . . . as may be necessary to carry out the provisions of this [Act]").

[28] *United Video, Inc. v. FCC*, 890 F.2d 1173, 1183 (D.C. Cir. 1989); *see also FCC v. Nat'l Citizens Comm. for Broad.*, 436 U.S. 775, 793 (1978) ("[I]t is now well established that [Section 303(r)] supplies a statutory basis for the Commission to issue regulations codifying its view of the public-interest licensing standard, so long as that view is based on consideration of permissible factors and is otherwise reasonable."); *United States v. Storer Broad. Co.*, 351 U.S. 192, 202-03 (1956) ("47 U.S.C. § 154(i) and § 303(r), 47 U.S.C.A. §§ 154(i), 303(r), grant general rulemaking power not inconsistent with the Act or law."); *Cellco P'ship v. FCC*, 700 F.3d 534, 542-43 (D.C. Cir. 2012) ("section 303(r) … supplements the Commission's ability to carry out its mandates via rulemaking").

[29] *Freeman v. Burlington Broads., Inc.*, 204 F.3d 311, 320 (2d Cir. 2000); *see also Sw. Bell Wireless Inc. v. Johnson Cty. Bd. of Cty. Comm'rs*, 199 F.3d 1185, 1192 (10th Cir. 1999)

authorizes then—if not directs—the Commission to adopt a TDD synchronization requirement in order to prevent harmful interference from C-Band licensees into the CBRS band.

The Commission has relied on this broad authority in other bands to mitigate harmful interference by imposing requirements on network operations rather than or in addition to adopting limits on power or emissions. In the Advanced Wireless Service band, for instance, it adopted requirements regarding power duty cycle[30] pursuant to various subsections of Section 303, including subsections (f) and (r).[31] More recently, the Commission has required that a contention-based protocol be adopted by unlicensed equipment operators transmitting in the 6 GHz band (relying in part on Section 303),[32] and specified which frequencies can be used for uplink and downlink operations in the 900 MHz band.[33] Imposing technical requirements on radio operations in order to avoid harmful interference is therefore fully consistent with past practice and the Commission's authority under the Communications Act. Accordingly, the Commission can rely on its Section 303 authority to require C-Band licensees to make TDD synchronization available to CBRS operators upon request.

(indicating that the Commission's authority under Section 303(f) allows it to generally regulate issues concerning radio frequency interference).

[30] 47 C.F.R. § 27.50(d); *see also In re Biennial Regulatory Review -- Amendment of Parts 1, 22, 24, 27 & 90 to Streamline & Harmonize Various Rules Affecting Wireless Radio Services*, Third Report and Order, 23 FCC Rcd 5319, 5348-49, App. A (2008) ("*AWS Order*").

[31] *See AWS Order*, 23 FCC Rcd at 5345 ¶ 64.

[32] *See In re Unlicensed Use of the 6 GHz Band*, Report and Order and Further Notice of Proposed Rulemaking, ET Docket No. 18-295, FCC 20-51, ¶¶ 101, 264 (rel. Apr. 24, 2020); *see also id.* ¶ 84 & n.215.

[33] *In re Review of the Commission's Rules Governing the 896-901/935-940 MHz Band*, Report and Order, Order of Proposed Modification, and Orders, WT Docket No. 17-200, FCC 20-67, ¶ 181 & App. A § 27.1506 (rel. May 14, 2020).

CONCLUSION

For these reasons, the Commission should reconsider its *C-Band Order* as set forth above to prevent C-Band operations from causing harmful interference to CBRS operations by requiring that TDD synchronization is made available to CBRS operators when requested. Taking such action will allow both the C-Band and the CBRS band to remain available for innovative 5G use, thereby ensuring that these bands will be put to their highest and best use in an expedited fashion.

Respectfully submitted,

/s/ Elizabeth Andrion

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ATTACHMENT

C-Band/CBRS Interference

Summary

- Charter has further studied issues with C-Band and CBRS co-existence and found Downlink-to-Uplink (BS-to-BS) interference is the most important concern.

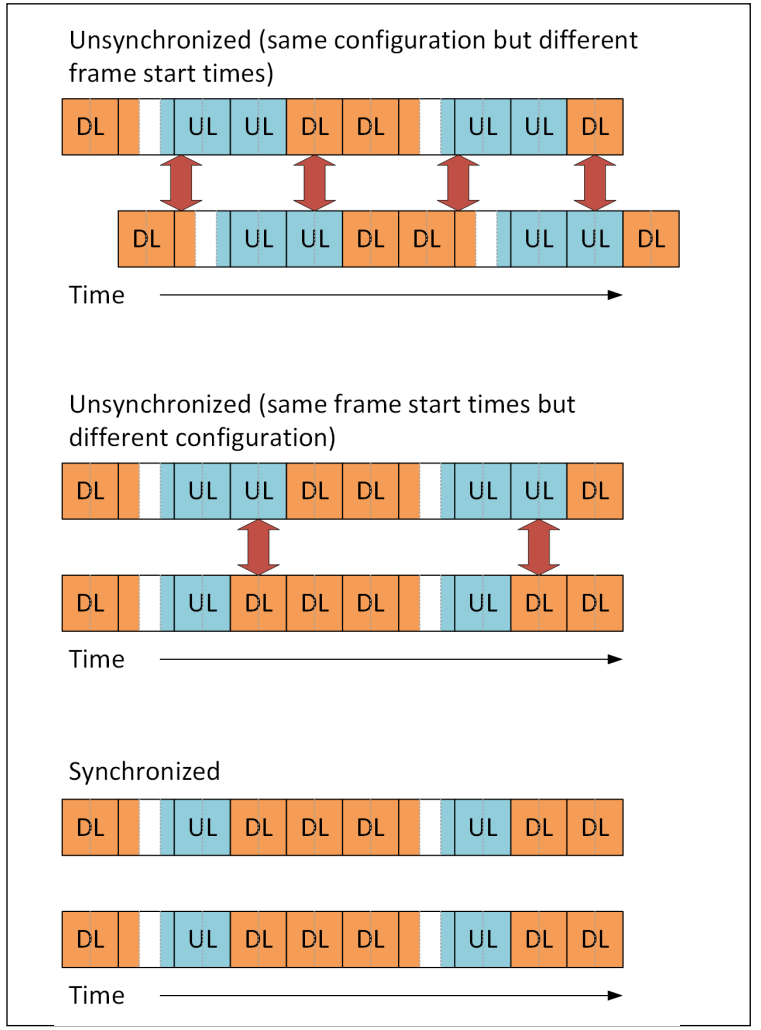
- This interference is dominated by **blocking**, with the consequence that **it affects the entire CBRS band**, including PAL and GAA operations

- This problem can be addressed by mandating TDD synchronization between C-band and CBRS networks.

Avoiding Downlink Next to Uplink

- It is widely accepted that downlink and uplink should not be assigned in directly adjacent spectrum
  - See for example the layout of 800, Upper 700, Lower 700, and 600 MHz FDD bands
- But with two adjacent TDD bands, both bands are used for uplink at some times and downlink at other times, so unless the relevant networks are synchronized, there will be adjacent uplink and downlink.
- The most likely deployment for both CBRS and C-Band is TDD, and these bands are directly adjacent at 3700 MHz with no guard band

TDD Synchronization



Downlink-to-Uplink Interference

- Both downlink-to-uplink (BS-to-BS) and uplink-to-downlink (UE-to-UE) can occur between unsynchronized TDD bands

- Charter's analysis shows that the most important issue is the BS-to-BS interference

- In the C-band-to-CBRS case, this means that the CBRS UE is transmitting to the CBRS BS, and that BS, as it tries to receive from the UE, is being interfered with by C-Band BS transmissions in the adjacent spectrum

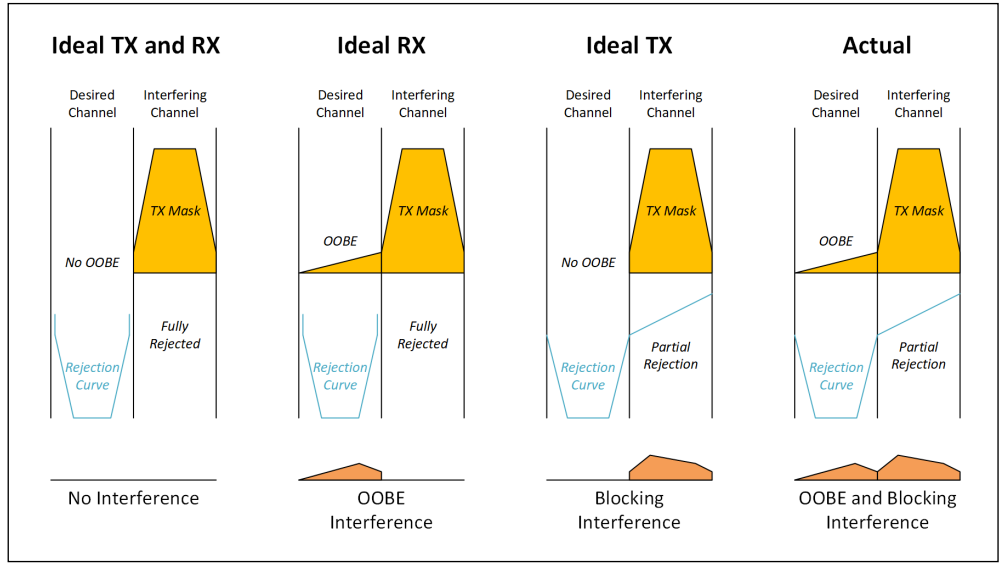
Overview of Adjacent Channel Interference

Out-of-band emissions

- Transmitters generally emit some power outside their channel – out-of-band emissions (OOBE)
- Characterized by some roll-off, will get better as frequency separation increases
- Typically this roll-off is a combination of gradual in-band roll-off and then better out-of-band roll-off from a band filter

Blocking

- Receivers generally cannot reject all the power outside their channel – blocking or overload can occur if enough power leaks through
- Similar to OOBE, characterized by little roll-off inside the band, as the receiver's low-noise amplifier (LNA) must operate across the whole band plus some margin, and power at any frequency in the LNA can overdrive it
- Outside of band, roll-off driven by RF filter or filtering effects of LNA and other components
- Typically only an issue when the undesired adjacent signal is significantly stronger than the desired signal



Overview of “ACIR” Methodology

ACLR = Adjacent Channel Leakage Ratio

- Ratio of total OOBE received by victim to total power in aggressor carrier
- Determined from OOBE and bandwidth

ACS = Adjacent Channel Selectivity

- Ratio of adjacent aggressor power to equivalent in-band interference
- Driven by receiver filtering and receiver overload or saturation (blocking)
- Determined from blocking and ACS specs and bandwidth

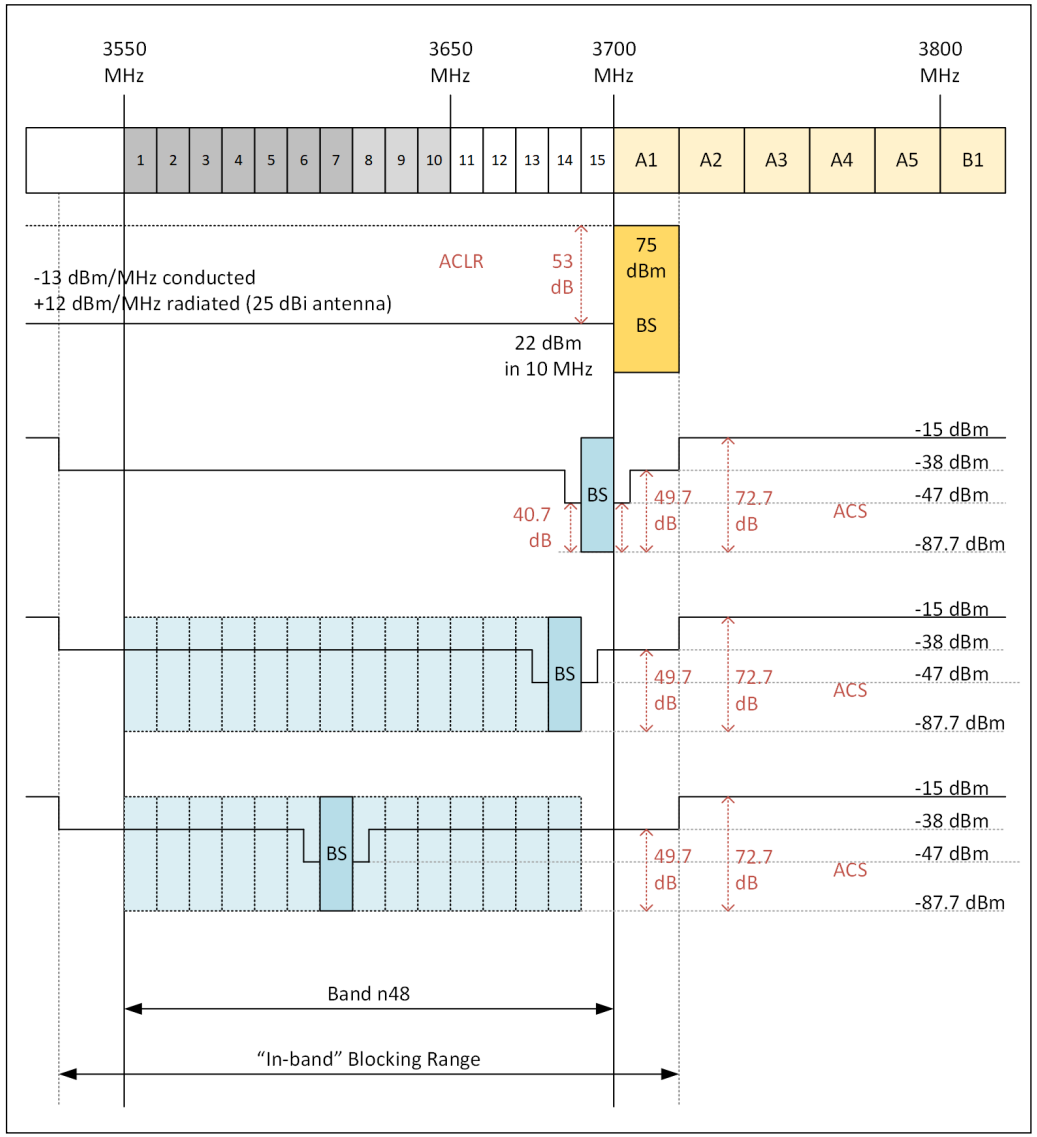
ACIR = Adjacent Channel Interference Rejection

- Ratio of total power in aggressor channel to an equivalent interference power in the victim channel
- Combination of ACLR and ACS - treats them as two sources of noise which can be added
- ACIR methodology is used in the 3GPP co-existence studies in TR 36.942 and TR 38.803

Determining CBRS BS ACIR

- CBRS BS receiver
  - Adjacent channel selectivity, blocking, and receiver sensitivity as per 3GPP TS 38.104 “Medium Range BS”
  - While adjacent channel specification moves with receive channel, in-band blocking specification does not, and is constant across the band and an additional 20 MHz on each side
  - This reflects the reality that any in-band power in the LNA will cause blocking regardless of the in-band frequency separation
- ACIR is dominated by ACS
  - All CBRS channels at essentially the same level, with the exception of the very highest channel which is a little worse (3.4 dB)
  - This means PALs and GAA are both impacted:

Blocks	1-14	15
ACLR (dB)	53.0	53.0
ACS (dB)	49.7	45.3
ACIR (dB)	48.0	44.6



Static Analysis Results

- Model summary:
  - C-band EIRP limit of 1640 W/MHz is 75 dBm in 20 MHz, this is achievable with expected massive MIMO base stations in C-Band
  - ACIR as above
  - 11 dBi receive antenna representative of small cells
  - Winner II Suburban line-of-sight (LOS) propagation
  - Used an aggressive setting of interference threshold to receiver sensitivity level, rather than more conservative criteria such as -6 dB I/N
- Result:

  Separation distances significantly higher than likely C-Band inter-site distances, meaning CBRS BS subject to interference over entire area of C-Band deployments

Blocks	1 to 14	15	
Transmitter			
Transmitter radiated power	75.0	75.0	dBm
ACIR	48.0	44.6	dB
Equivalent on-channel power	27.0	30.4	dBm
Receiver			
Sensitivity	-93.7	-93.7	dBm
Receive antenna gain	11.0	11.0	dBi
Interference threshold	-104.7	-104.7	dBm
Required path loss	131.7	135.1	dB
LOS separation distance	**8.2**	**11.4**	**km**

Probabilistic Analysis Approach

- **Incorporate probabilistic factors that may mitigate interference in practice**
  - Model CBRS network and interfering C-Band sites
  - Iterate both over multiple network laydowns and sample UE locations for each laydown
  - Include shadow fading, antenna orientations, random UE locations, and deviations from perfectly hexagonal grids
  - Assume C-Band beamforming reduces power towards CBRS BS in many instances
- **When the desired UE signal is received at a higher power, more resistant to BS interference**
  - Calculate uplink SNR for each sample UE location with and without C-Band interference
  - Tabulate locations where delta causes signal to be lost as the SNR drops below the requirement for the lowest modulation and coding scheme (MCS)
  - Tabulate average uplink throughput reduction on locations that maintain a connection
- **Estimate probability of LOS between aggressor and victim base stations**
  - Base estimates on 3GPP/NYU/Winner II work on LOS probabilities, including adjustments for receiver height

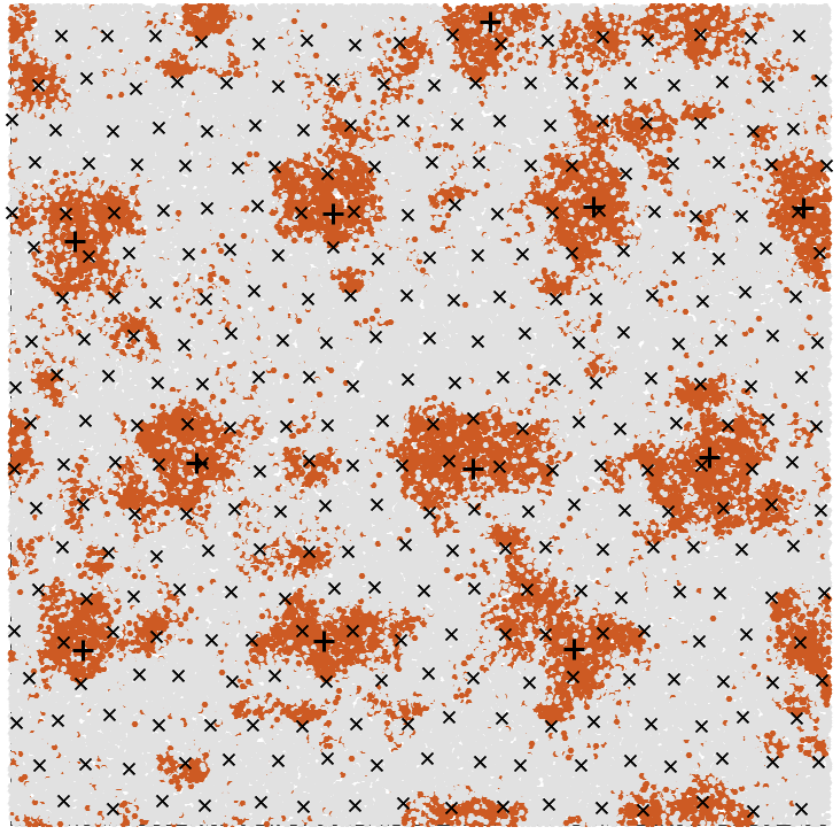
Probabilistic Analysis Results

- **Results show interference at unacceptable levels**
  - The clustering of locations where coverage was lost in the figure show that often most or all locations on a particular sector will be lost when that sector receiver is overloaded
  - Interference also clusters around the C-band base stations

Blocks	1-14	15
Locations where coverage was lost	21.7%	30.3%
Average throughput reduction in all other locations	22.9%	30.0%

- These results are for a C-Band network using massive MIMO antennas with 1.5 km ISD and 30 m heights, while the CBRS network has three-sector sites with a 300 m ISD and 10 m antenna heights.

Snapshot of one layout for blocks 1-14



Red dots: iterations where coverage was lost
Grey dots: iterations where coverage was maintained
Black x's: CBRS BS locations for this snapshot
Black crosses: C-band BS locations for this snapshot